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WATER WORKS IMPROVEMENTS AT AKRON, OHIO[1]

By G. Gale Dixon[2]

Water supply in Akron has been complicated during recent years by a very rapid growth in the city, so rapid that many persons who should be living in it in order that the large industrial population may be surrounded by normal conditions are actually unable to find accommodations. This condition is so unusual and affects estimates of the population to be supplied with water in the future so materially that it deserves particular attention. In 1919 the population was 175,000 and the ratio of this total population to the number of persons engaged in the city's industries was 2.5. In 1910 the population was only 69,000 and its ratio to industrial employees was 3.5, about the same ratio as existed in Paterson, N. J., and Bridgeport, Conn., in that year. The ratio of 3.5 is about the smallest which is possible when the city has homes for the families of all its industrial workers and affords adequate public utilities, stores, eating places, amusements, schools, professional men and other elements of a reasonably balanced municipality. If all the industrial employees now in Akron were able to bring their families to the city and give them the facilities which they are justified in expecting in a thriving American city of this class, the population would be about 250,000 today. This is clearly shown by the ratio of total population to industrial employees in other manufacturing cities; Pittsburgh, Pa., population 533,900 in 1910 and a ratio of 5.1; Indianapolis, 116,100 and 5.0; Columbus, Ohio, 181,500 and 5.4; Worcester, Mass., 146,000 and 4.1; Camden, N. J., 94,500 and 4.3. It is obvious that a properly balanced condition of the population can only be realized by expanding housing facilities and public utilities and improvements more rapidly than the industries develop. The improvement of the water works which the voters authorized last year was based on this view of the existing conditions and is the minimum which those in charge of the work regard as meeting the unusual situation in the city.

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[1] Discussion of this paper is requested and should be sent to the Editor.

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The very rapid growth of the city is shown in figure 1, which also shows the rate of growth of a number of other American cities after they attained a population of 200,000. Akron's recent growth has never been paralleled during any great period of time by any city except Chicago, and the lack of natural advantages in the Akron district makes a long continuation of such rapid development unlikely. It is certain, however, that with an adequate program for housing and public improvements, the continued expansion of industries will raise the population to very nearly 300,000 by 1925. It is believed that the district can be developed to support a population of a million, but such numbers need not be considered at this time.

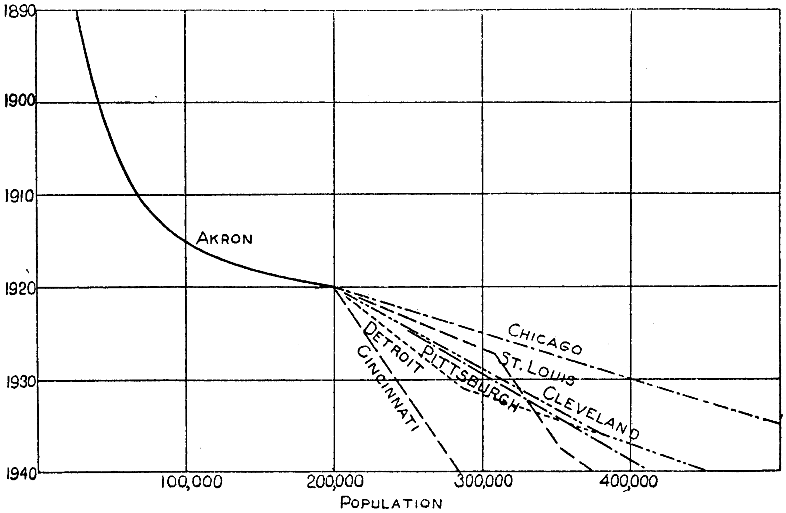


Fig. 1. Growth of Population of Akron and of Other Cities After Reaching 200,000 Population

Municipal water supply in Akron dates from April 1, 1912, when the city took over the plant of the Akron Water Works Company, for which it paid $815,000. The supply was both poor and inadequate and the plant was not large enough for the needs of that day. Work was immediately begun on new works under the direction of F. A. Barbour and E. G. Bradbury, consulting engineers, and in August, 1915, water was delivered by them to the city. The supply is obtained from the Cuyahoga River, which was dammed about 3 miles above Kent. The drainage basin above the dam has an area of 206 square miles. The reservoir, called Lake Rockwell, holds about 2,385,000,000 gallons and can be relied on to supply 30,000,000 gallons daily in time of drought. By placing flashboards on the dam the water can be raised 3 feet and the supply increased to 35,000,000 gallons daily, a quantity sufficient for a population of about 300,000. The watershed is probably capable of further development at reasonable cost to furnish a supply of 100,000,000 gallons daily.

The water flows from the reservoir to a purification plant through a 48-inch cast iron pipe line about half a mile long. In order to maintain a gravity flow of large quantities of water through the purification plant a parallel raw water line must be constructed, provision for which was made in the original construction work.

Before filtration the water, after treatment with alum, passes through underground storage basins of 2,000,000 gallons capacity. This capacity is inadequate for satisfactory sedimentation at the present rate of operation. In 1919, when the raw water carried a large quantity of microscopic vegetable matter, the period of operation of filters between washings was reduced at times to 45 minutes and it was necessary to use all the filters to meet the demands for water. It is accordingly proposed to increase the sedimentation basins to a total capacity of 4,700,000 gallons. This will give a two-hour detention period for the gross capacity of the plant after being enlarged as proposed, or about three hours for the estimated average demand.

The filtration plant has fifteen units of 2,000,000 gallons each, of the rapid sand type. Allowing for one unit in reserve and 10 per cent of the water to be used in the operation of the plant, the net maximum capacity is 25,000,000 gallons daily. This is equivalent to the maximum demand on the plant during a year when the consumption averaged about 20,000,000 gallons daily. It is expected that this demand will be reached or exceeded during the current year. Plans are accordingly being made for the construction of eleven more units of the same size, which will give a total gross capacity of 52,000,000 gallons, enough to maintain satisfactorily peak load conditions during a year with an average consumption of 35,000,000 gallons daily.

The pumping station serves four purposes, lifting water to the filters when the level in the storage reservoir is too low to permit the usual gravity flow through the filter plant, forcing the purified water to the city through an 11-mile force main, furnishing electric current for lighting and power about the plant, and supplying steam for the equipment to perform the functions mentioned.

There are two low-lift pumps, one of 17,000,000 gallons daily capacity and one of 25,000,000 gallons capacity. Another 25,000,000-gallon pump, with perhaps a fourth of smaller size, will bring the present equipment up to the capacity of the enlarged purification plant. The station contains two triple-expansion pumping engines with a normal rated capacity of 14,000,000 and 15,000,000 gallons respectively, and a 10,000,000-gallon turbo-centrifugal pump, for the high-lift service. With continued careful operation this plant will suffice for a year having an average consumption of about 24,000,000 gallons. The present plan is to add a 20,000,000-gallon triple-expansion pump. Counting this as a reserve and running the three present pumps at their maximum capacity, which is 7,000,000 gallons above their normal capacity, an output of 46,000,000 gallons daily can be maintained, equivalent to the peak load during a year with an average consumption of 35,000,000 gallons.

The original boiler plant had three 200-horse power hand-fired boilers and in 1918 two 300-horse power boilers were added. It is proposed to substitute two 300-horse power boilers for the three small units, install mechanical stokers under all the boilers and put in an induced draft fan system. Later another battery of 300-horse-power boilers must be installed. The improvements now proposed also include increasing the coal storage, installing a full equipment of economizers and rearrangements of the plant which will remedy its overcrowded condition in some places.

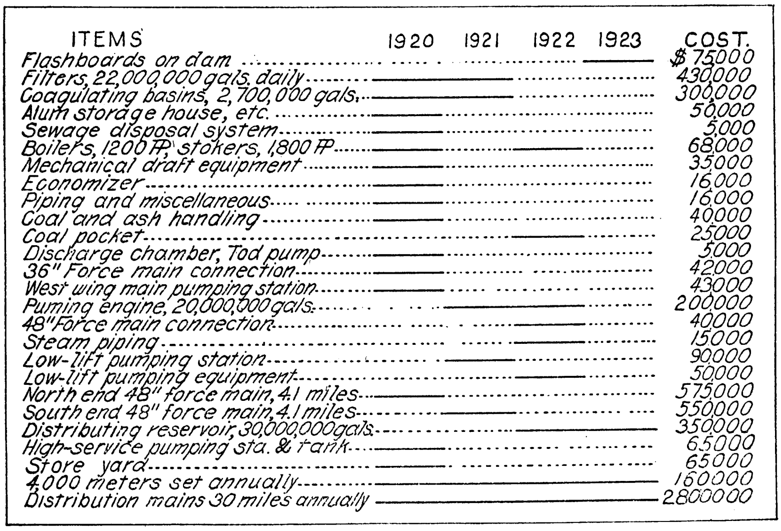
The original force main was a 36-inch lock-bar steel pipe. About $2\frac{1}{3}$ miles of its length have already been paralleled by a 48-inch pipe of the same type and about 4 miles more are now under construction. The new line is being cross-connected to the old one at intervals of about a mile. The remainder of the new line will be laid next year. The difference in elevation between the pumping station and the distribution reservoir in East Akron is 165 feet. The high-lift pumps and force main were designed for a maximum head of 290 feet at the pumps, leaving about 125 feet pressure head at the pumping station available for overcoming friction in the force mains. Tne original 36-inch pipe had sufficient capacity with 290 feet total head at the station to handle the peak loads of a year with an average consumption of about 16,000,000 gallons per day.

The result of reinforcing 2⅓ miles of its length with a 48-inch pipe has been to raise its capacity for the peak of a year with 18,000,000 gallons average daily draft, a rate which has already been exceeded, showing that the force main is obviously in need of the reinforcement now in progress. The two mains, 36 and 48-inch, will deliver 35,000,000 gallons daily with a total head of 220 feet on the pumps, which is the head for maximum efficiency for the pumps, while a peak load of 46,000,000 gallons per day will increase the head to but 250 feet.

The water is delivered to a distributing reservoir in East Akron which holds about 20,000,000 gallons, approximately the average daily consumption at present. The city has bought land near this reservoir for additional basins which will bring the total capacity to about 100,000,000 gallons. The present improvements contemplate the construction of a 30,000,000 gallon basin, making the total storage capacity 50,000,000 gallons, or about the maximum 24-hour demand during a year with an average consumption of 35,000,000 gallons.

These notes of work to be done as rapidly as possible must be read in the light of the fact that it was only five years ago that the new works were put in service, and this extensive additional work is not the first enlargement of the municipal system. The city grew so fast that in 1917 $3,110,000 had to be provided, part of which was used in bringing the supply system to the condition just described and part in laying about 70 miles of street mains, installing a universal meter system and providing booster pumps and elevated water tanks for two high-service districts. Today there are 120 miles of street mains to be laid in order to give the service which should be afforded, and the improvement program provides for at least 30 miles of this work annually. The various stages in which it is proposed to carry on the work are scheduled in figure 2.

While the engineering features of the new work are interesting, the business aspect of the Akron water works is possibly still more interesting. Figure 3 shows the population and water consumption of the city for the last ten years and two estimates for future conditions, one assuming that the city reaches 300,000 population in 1925 and one that it attains this size in 1930. The capacity of the present elements of the water works is also shown. It will be seen that in 1918 and 1919 the consumption and population curves have been drawing together, indicating a reduction in the per capita consumption of water. This condition may be partly due to the reduction of waste by universal metering, but the main factor is probably the compliance of manufacturers with requests to hold down their consumption to the minimum. The program of new work is based on the use of 120 gallons per capita, which is believed to be moderate for Akron conditions.



ITEMS	COST.
Flashboards on dam	$75000
Filters, 22,000,000 gals. daily	430000
Coagulating basins, 2,700,000 gals.	300000
Alum storage house, etc.	50000
Sewage disposal system	5000
Boilers, 1200 HP, stokers, 1800 HP	68000
Mechanical draft equipment	35000
Economizer	16000
Piping and miscellaneous	16000
Coal and ash handling	40000
Coal pocket	25000
Discharge chamber, Tod pump	5000
36" Force main connection	42000
West wing main pumping station	43000
Puming engine, 20,000,000 gals.	200000
48" Force main connection	40000
Steam piping	15000
Low-lift pumping station	90000
Low-lift pumping equipment	50000
North end 48" force main, 4.1 miles	575000
South end 48" force main, 4.1 miles	550000
Distributing reservoir, 30,000,000 gals.	350000
High-service pumping sta. & tank	65000
Store yard	65000
4,000 meters set annually	160000
Distribution mains 30 miles annually	2800000

FIG. 2. PROGRESS SCHEDULE, AKRON WATER WORKS IMPROVEMENTS

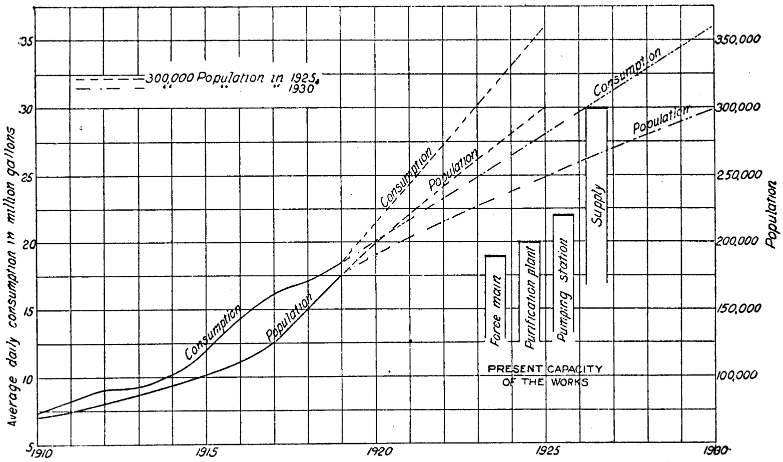


FIG. 3. POPULATION AND WATER CONSUMPTION CURVES, AKRON

Information regarding past financial conditions, furnished by H. H. Frost, superintendent of the Bureau of Water Supply, is shown on figure 4. Lines have been drawn extending these data into the future to indicate the financial conditions which will result from proceeding with the construction program, with income (based on present water rates) increasing according to two different assumptions, first, the population increasing to 300,000 in 1925, and, second, the population reaching that figure in 1930. The diagram covers cash income only, no credit being shown for water supplied to the city or to charitable institutions.

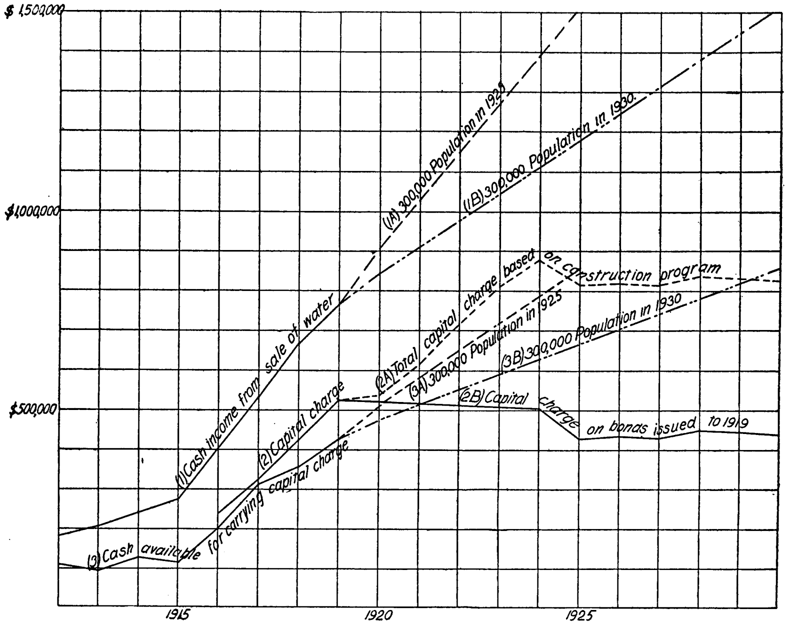


FIG. 4. FINANCIAL DATA REGARDING AKRON IMPROVEMENTS

Line (1) Extensions (A) and (B) are based on income of $115 per million gallons of water at the current rates.

Line (2) is based on the standard amortization method of retiring sinking-fund bonds.

Line (3) Cash Available for Carrying Capital Charge is the difference between Cash Income (Line 1) and the cost of operation and maintenance. Extensions (A) and (B) are based on a cost of $50 per million gallons for the cost of operation and maintenance.

No credit is taken in this diagram for service supplied free to other city departments.

It will be seen that on the first assumption there will be a deficiency in "cash available to carry capital charge" until 1925, substantially equal to the deficiency of the last few years. With the slower rate of growth this deficiency is larger and continues until 1930.

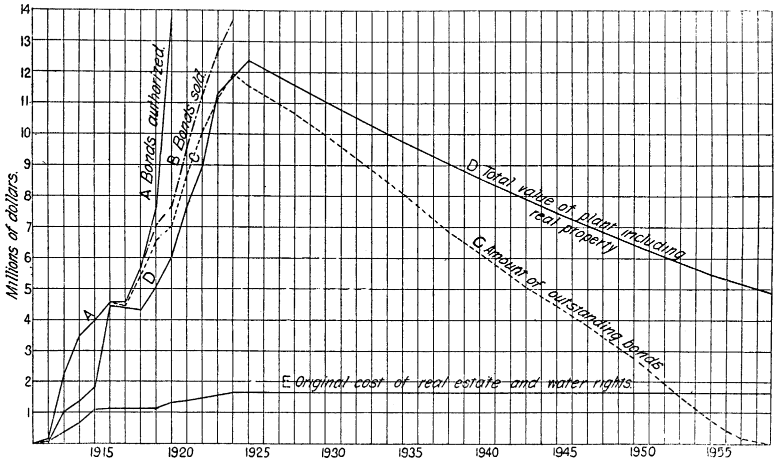


FIG. 5. ESTIMATED ASSETS AND LIABILITIES TO TIME OF FINAL RETIREMENT OF BONDS

B. Assumes bonds sold in accordance with construction program.

C. Assumes $6,685,000 to be issued as 5 per cent 35-year serial bonds arranged for equal total annual carrying charges. The average term of bond issues to 1919 (7,005,000) was 27.9 years, and the addition of $6,685,000 on the preceding terms raises the average to 31.4 years.

D. Assumes straight-line depreciation of structures and improvements at the following named years of useful life: Reservoirs, impounding and distributing, 75; purification plant, pumping station, brick and concrete buildings, 40; cast iron pipe lines and appurtenances, 75; steel pipe and tanks, 35; boiler plant, 15; vertical triple-expansion pumping engines, 40; other pumping equipment, 25; service meters, 15; dwellings, 15. Note that 11.8 per cent of the investment is in real property and that the average life of structures and improvements as set forth is 57.6 years.

E. Real property has been assumed of constant value at its original cost.

A continuation of the policy of compensating the water department through the sinking fund commission for water supplied free for public purposes and fire protection will wipe out this deficiency in the future as it has in the past and continue the department self-supporting at the present water rates. This is shown by the fol-

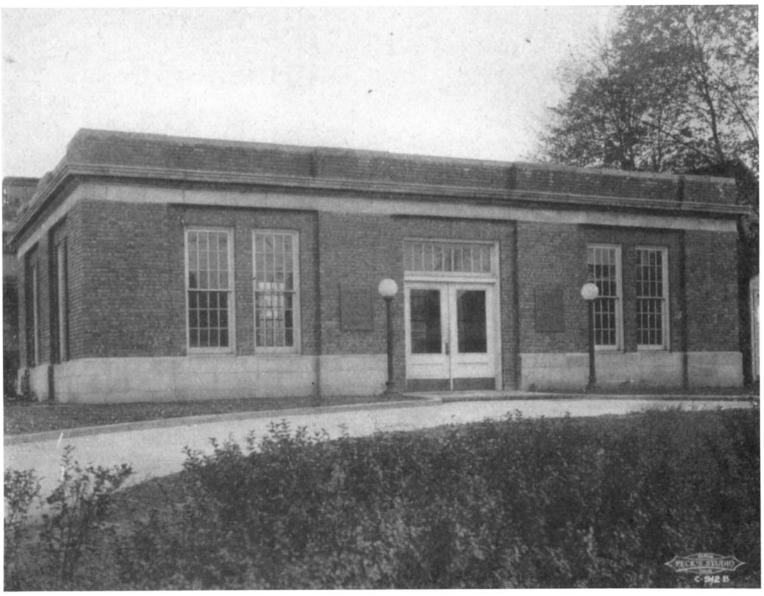


FIG. 6. EXTERIOR OF HIGH-SERVICE PUMPING STATION

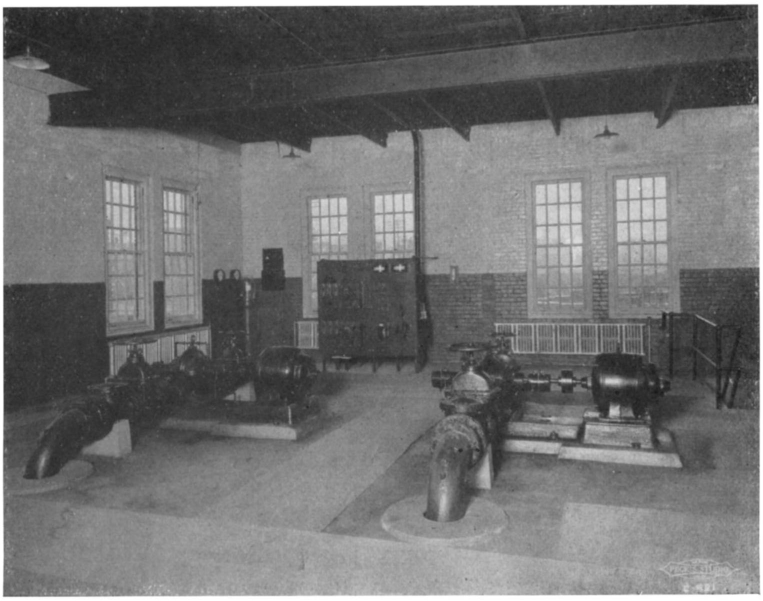


FIG. 7. INTERIOR OF HIGH-SERVICE PUMPING STATION

lowing figures, which assume allowances for free water to be made at the rate of $12 per million gallons of total water consumption.

(1) With the population increasing at the rate of 20,000 per year, reaching 300,000 in 1925, the department will operate continuously "at a profit," accumulating a surplus of about $400,000 by 1925. This assumes that no further bond issues are voted during this period.

(2) With the population increasing at the rate of 10,000 per year, reaching 300,000 in 1930, the department will operate with a deficit from 1921 to a maximum accumulation of indebtedness of $200,000 in 1925, after which date the deficit will be reduced and in 1929 there will be a surplus of about $100,000.

The allowance for free water and for fire service at the rate of $12 per million gallons of total consumption, as used above, is in substantial accord with the report of the State Auditor for the last two-year period covered by his reports, in which the "total free water service" was estimated at $145,848.46.

Figure 5 is a diagram prepared for the use of the city council in determining the life of water works bonds, which was finally fixed at 30 years.

Figures 6 and 7 are views of the exterior and interior of a high-service pumping station just built in the highest grade residential district in the city. The equipment consists of two motor-driven centrifugal pumps, each rated at 1,000 gallons per minute, arranged for automatic operation. Space is left for two larger pumps which will probable be needed later. The pumps are driven by Wagner motors controlled by a Golden-Anderson stop-starter controlling altitude valve, operating through relays on the pumping station switchboard. There are two stop-starters, throwing the pumps in at successive intervals in the drop of the water level in the water tank into which the station pumps. There is also a cross-over switch in the station so that either pump may be set to start first. The elevated tank was erected by the Chicago Bridge and Iron Works and contains 350,000 gallons, supported on a tower 75 feet high.